

## Patterns of Grazing on Coastal Dune Systems by Insular Populations of Two Species of Macropod

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### Abstract

A study of grazing patterns on a coastal dune system on South Stradbroke Island, Queensland, by two species of wallaby was undertaken. Utilisation of sand spinifex (*Spinifex sericeus*) by agile wallabies (*Macropus agilis*) and swamp wallabies (*Wallabia bicolor*) was highly variable between different sites on the dune system. Although wallaby activity on secondary dune strata was significantly higher than on the primary dune, this was not reflected statistically in spinifex grazing levels. However, spinifex stolons on the toe of the primary dune were heavily grazed. Grazing levels on dune systems on the island were negatively associated with the width of the frontal dune and the relative area of open forest vegetation adjacent to the dune system.

### Introduction

Frontal dune systems form part of one of the most dynamic terrestrial ecosystems in nature. The wind regime is predominantly responsible for determining the size and shape of foredunes, with vegetation responsible primarily for stability and dune structure (Brown and McLachlan 1990). In Australia, pioneer dune species such as *Spinifex sericeus* (sand spinifex) have an important role in stabilising the frontal dune area and creating conditions suitable for the establishment of other species. This species is characteristic of dune vegetation in that it produces upright leafy stems and vigorous root growth in response to sand burial (Maze and Whalley 1990). Whilst *S. sericeus* is able to survive in an extremely hostile environment and is able to tolerate large sand movements and erosion of the dunes, it is unable to cope with excessive physical damage such as that caused by vehicles or stock grazing (Barr 1981; Woodhouse 1982; McKenzie *et al.* 1988).

The response of vegetation to grazing pressure is dependent on a number of factors, including the rate of defoliation, which is itself dependent on the abundance and preference of the herbivores, the sensitivity of the plant to defoliation and the interactions with climate and soil (Wilson 1990). Limited studies on the response of frontal dune vegetation to herbivory suggest that vegetation on the primary dunes is preferred and that, at a stocking rate of 1 (ungulate) animal ha<sup>-1</sup>, spinifex cover was reduced within 6 months to the point where the ability of the dune system to trap windblown sand was significantly impaired (Barr *et al.* 1986).

South Stradbroke Island is an 18-km-long sand island off the Australian coast, south-east of Brisbane, Queensland (Fig. 1). The long-term stability of the frontal dune system on the island may be threatened by grazing pressure by the two species of wallaby that inhabit it, the agile wallaby (*Macropus agilis*) and the swamp wallaby (*Wallabia bicolor*). Macropod populations occur on other islands in Moreton Bay; however, only on South Stradbroke are

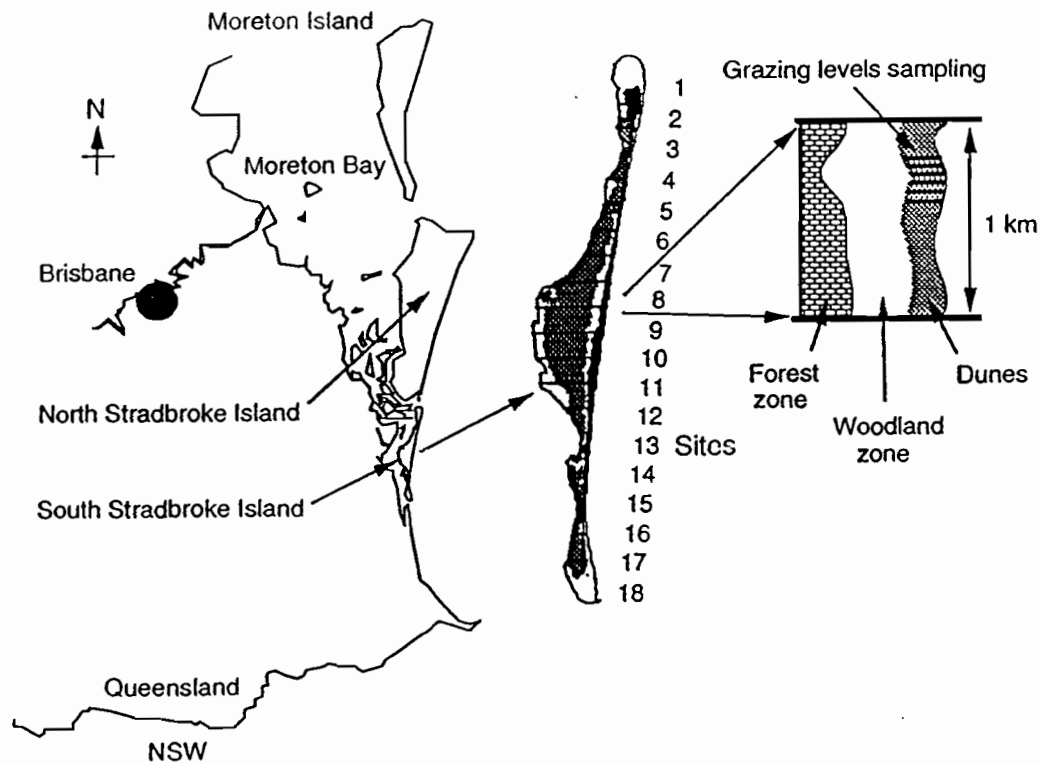


Fig. 1. Location of South Stradbroke Island and layout of sampling design.

they seen to be causing grazing problems. The disparity here with other island macropod populations is that, on South Stradbroke the two wallaby populations are believed to have increased significantly since the removal of cattle from the island in the mid-1970s and the creation of grassland areas as a result of the establishment of tourist resorts and camping grounds (B. Mason, personal communication). The swamp wallaby of South Stradbroke appears to be a subspecies of swamp wallaby originating from mainland populations and is only found in the islands of Moreton Bay (McEvoy 1976). The agile wallaby is considered a relict population, representing the southern range of a formerly more widespread mainland population that contracted northwards (Johnson 1980). Consequently, the nearest population of *M. agilis* occurs over 500 km to the north near Rockhampton (Covacevich 1984). While there is some evidence to suggest that grazing by introduced ungulates can have an impact on normal frontal dune processes, there are no data on these same interactions with native herbivores. Our study conducted in May 1991 assessed levels of grazing by wallabies on *S. sericeus* in different strata of the foredunes and the distribution of grazing along the length of South Stradbroke Island. This was the first step in determining whether grazing is a potential problem.

#### Materials and Methods

To examine the distribution of wallaby grazing on *S. sericeus* along the 18 km of the eastern dune system of South Stradbroke Island, we divided the coast into 18 1-km sites. At each of these sites, 6 transects spaced 50 m apart and running east to west from the toe of the primary foredune inland to the end of the frontal dune or to a maximum of 150 m were laid at a random starting position in the site. Quadrats 1 m<sup>2</sup> were laid every 3 m on each transect and the number of nodes of spinifex leaves in each quadrat and the number of grazed nodes recorded. *S. sericeus* has a stoloniferous habit and produces distinct groups of leaves at the nodes, which can facilitate counting. Evidence of wallaby

grazing was recorded if one or more leaves in a nodal group were 'picked', as wallabies are the only large grazing herbivores on the island. Only green leaves or new shoots were considered for counting, thus ensuring that the grazing occurred relatively recently. Each quadrat was categorised according to whether it was on the primary dune or other secondary dunes and the number of faecal pellets in each quadrat was recorded (Fig. 2). Only whole, unweathered pellets were counted and no attempt was made to distinguish between faecal pellets of the two species.

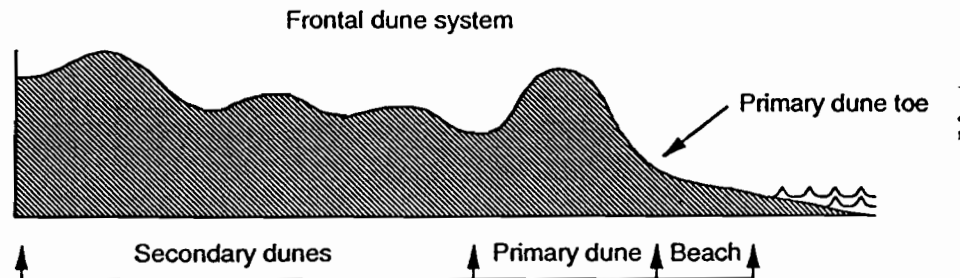


Fig. 2. Typical dune profile of South Stradbroke Island, showing terminology used for different strata.

As spinifex stolons are important in the colonisation of sand accretion on the primary foredune, strip transects 10 m long and 1.5 m wide were placed along the toe of the primary dune in order to assess grazing levels in this important area of dune formation. These transects were perpendicular to each of the 6 transects in the site. Each spinifex stolon that was intercepted by the transect was examined as to whether the terminal end was grazed (i.e. picked) (Fig. 2). Estimates of the proportion of spinifex nodes grazed within each site were calculated by averaging the proportion grazed from all quadrats that contained at least 1 spinifex node. We performed this separately for the primary and secondary dune areas. The data from each of the strip transects along the toe of the primary dunes were combined to estimate the proportion of leading stolons that had been grazed within each site.

Generally, four major vegetative zones can be described in coastal areas (Doing 1985) and, on South Stradbroke, three of these zones can be clearly delineated. These are zone 1, representing pioneer zone vegetation, zone 2, which consists predominantly of a shrub heath or woodland community, and zone 4, which consists predominantly of open forest vegetation. As South Stradbroke is quite narrow in places, areas of zone 4, the forest zone, may be minimal in area or absent as a result of insufficient protection from wind and salt spray. Other studies of macropodids have documented that, generally, the highest densities of macropods occur where the habitat is heterogeneous (Floyd 1980; Hill 1981; Pople 1989). Therefore, the area and spatial distribution of vegetative zones adjacent to dune areas could potentially affect the amount of grazing occurring on the frontal dunes by describing the amount and composition of alternative vegetation types available to the wallabies. In order to describe these broad environmental patterns, variables describing the physical and vegetative characteristics of the island at each site were tabulated from topographic and vegetative maps. The width of the island, the width of the dune areas, the ratio of forest-zone vegetation to woodland-zone vegetation, and the ratio of dune width to vegetated width (forest-zone + woodland-zone vegetation) were determined for each site.

The dynamic nature of foredunes and differences in microclimate between sites may have resulted in differences in *S. sericeus* node density between sites. To determine whether *S. sericeus* node density, and hence vegetation density on the dunes, was influencing wallaby grazing levels, the mean density of nodes per quadrat on primary and secondary dunes was calculated for each site.

To determine variables potentially associated with grazing pressure, Pearson correlation coefficients were calculated between the three grazing variables (proportion of nodes grazed on primary dunes and on secondary dunes, and proportion of stolons grazed on primary dunes) and the island-characteristic variables and density of nodes on primary and secondary dunes. Correlations were also calculated between grazing variables and faecal pellet counts and spinifex node density to determine whether the grazing measurements were representative of wallaby feeding activity.

## Results

A total of 2885 quadrats were sampled. The 337 quadrats that did not contain any spinifex nodes were excluded from the analyses except when calculating node density estimates for each site. The number of quadrats sampled in each site depended on the width of the frontal dune area and ranged from 79 to 269.

### *Grazing Levels on Primary Dunes*

The percentage of spinifex nodes on the primary dune that were grazed ranged from 1.0 to 57.6% ( $\bar{x}=18.7\%$ ,  $s.e.=4.0\%$ ). The stolons along the toe of the dunes were more highly grazed, ranging from 14.8 to 73.1% ( $\bar{x}=43.2\%$ ,  $s.e.=4.3\%$ ). Even in sites where grazing on the primary dune was low, the leading stolons were still subject to intensive grazing by wallabies. For example, 1 site with minimal grazing on the front dune still had 42.8% of the sampled stolons grazed (Fig. 3).

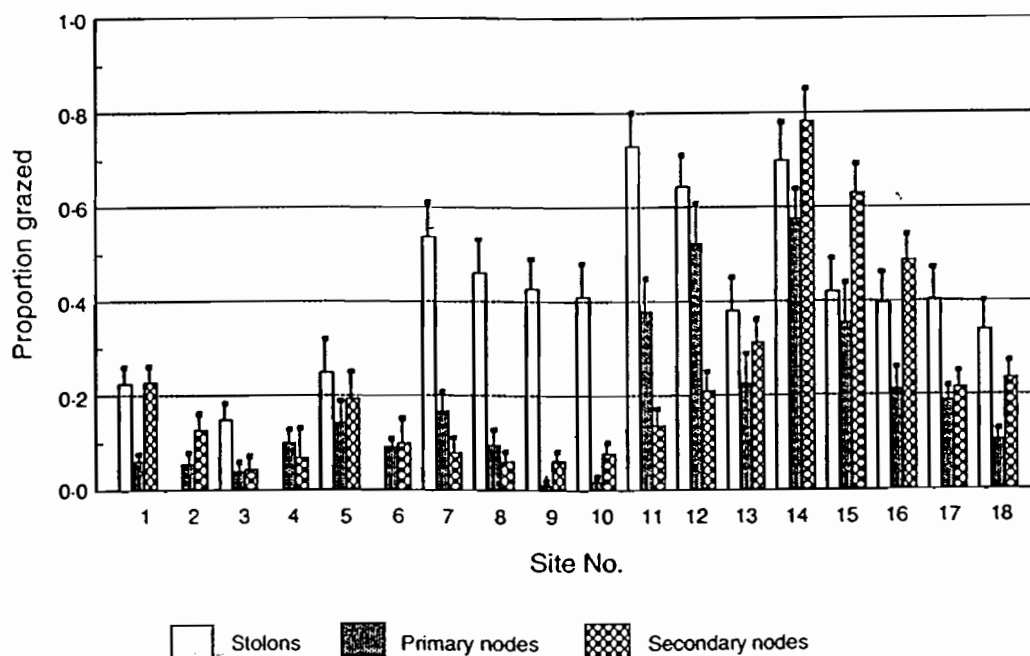


Fig. 3. The proportion of grazed nodes on primary and secondary dunes and on stolons (+s.e.) at each site.

The proportion of spinifex nodes grazed on primary dunes was negatively correlated with dune width and the forest-zone to woodland-zone vegetation ratio. The density of nodes on the primary dune was consistently higher than on the secondary dune (Fig. 4); however, no correlation was found between density of nodes on the primary dune and grazing levels on the primary dune and no correlations were found for proportion of stolons grazed (Table 1).

### *Grazing Levels on Secondary Dunes*

The proportion of the spinifex nodes in the secondary dunes that were grazed ranged from 4.4 to 78.2% ( $\bar{x}=22.5\%$ ,  $s.e.=4.9\%$ ) (Fig. 3). This variable was negatively correlated with the forest-zone to woodland-zone vegetation ratio and island width (Table 1). Thus, sites that were associated with a smaller proportion of forest-zone vegetation than woodland-zone vegetation were more susceptible to grazing on both the primary and secondary dunes.

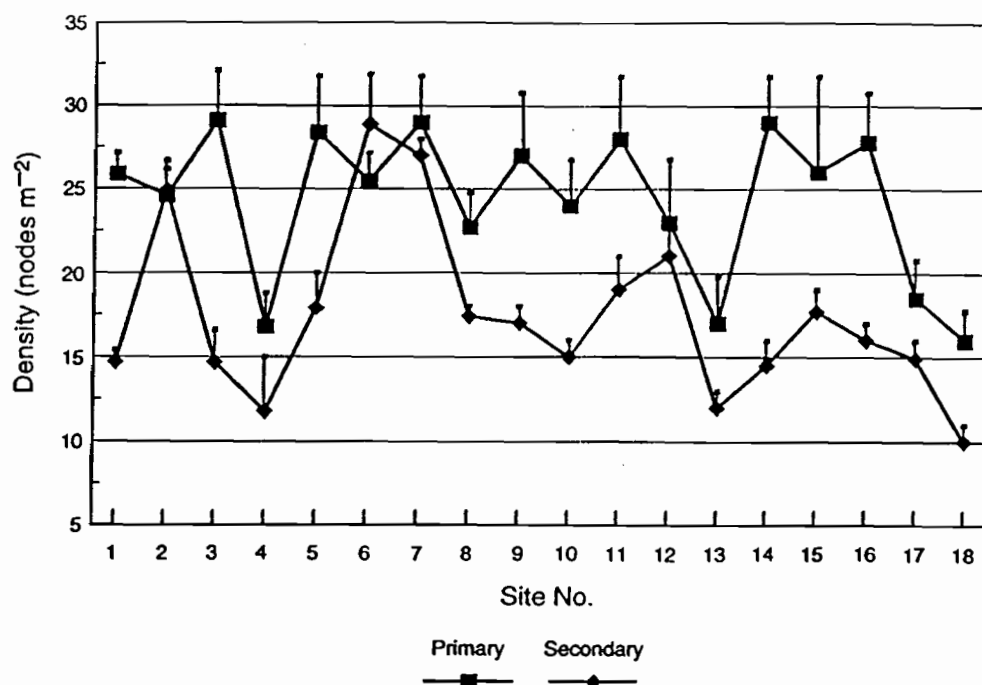


Fig. 4. The density of nodes (+s.e.) on primary and secondary dunes at each site.

Table 1. Correlation of some environmental variables with the proportion of grazed nodes and stolons on primary and secondary dunes

Variable	Primary		Secondary		Stolons	
	Pearson correlation coefficient	<i>P</i>	Pearson correlation coefficient	<i>P</i>	Pearson correlation coefficient	<i>P</i>
Island width	-0.24	0.33	-0.50	0.03	0.29	0.28
Dune width	-0.53	0.03	-0.42	0.08	-0.31	0.26
Dune-vegetation ratio	0.07	0.77	0.41	0.09	-0.06	0.85
Forest-woodland vegetation ratio	-0.47	0.05	-0.79	0.0002	-0.19	0.49
Spinifex node density	0.15	0.54	-0.25	0.32	—	—

A comparison between dune strata showed that grazing levels on secondary dune strata were not significantly different from those on the primary dunes ( $t_{17}=1.07$ ,  $P=0.29$ ). As for primary dunes, no correlation was found between spinifex node density and grazing levels on the secondary dunes (Table 1).

#### Faecal Pellet Counts

The index of wallaby-feeding activity on the primary dunes, as measured by faecal pellet counts, ranged from 0 to 0.79 pellets per quadrat ( $\bar{x}=0.31$ , s.e.=0.053) and was positively correlated with the proportion of grazed spinifex nodes on the primary dunes ( $r=0.72$ ,  $n=18$ ,  $P=0.0007$ ) and the proportion of leading stolons grazed ( $r=0.83$ ,  $n=15$ ,  $P=0.0001$ ).

Faecal pellet counts on the secondary dunes were significantly higher than on the primary dune ( $t_{17}=5.74$ ,  $P<0.001$ ), ranging from 0 to 2.95 pellets per quadrat ( $\bar{x}=1.24$ , s.e. = 0.174). Pellet counts from secondary dunes were correlated with the proportion of spinifex grazed on the secondary dunes ( $r=0.60$ ,  $n=18$ ,  $P=0.008$ ) (Fig. 5). No correlation was found between spinifex node density and faecal pellet counts for either primary or secondary dune areas.

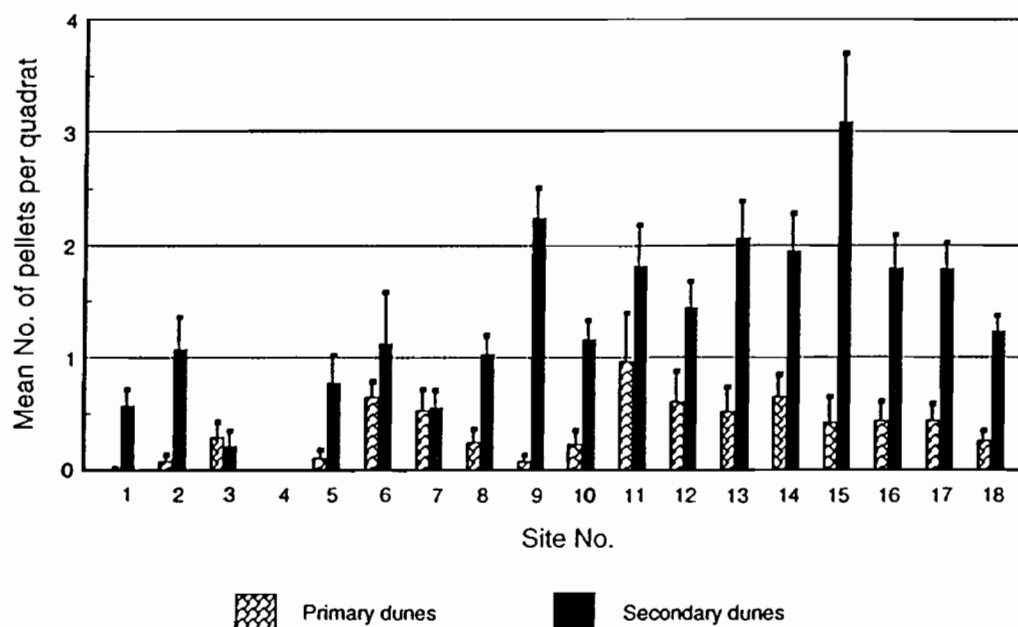


Fig. 5. Mean faecal pellet count (+s.e.) on primary and secondary dunes at each site.

## Discussion

Grazing that occurred on frontal dunes was highly variable in intensity both in distribution along the island and within the various strata of the dunes. Levels in some sites reached 73.1% of stolons grazed and 57.6 and 78.2% of nodes grazed in primary and secondary dunes, respectively. Despite this variation in grazing intensity, grazing levels between primary and secondary dune strata overall were not significantly different. This was, however, not reflected in the faecal pellet counts. Even though pellet counts had significant positive correlations with grazing on primary and secondary dunes, this alone did not account for grazing levels in each area, as differences in grazing levels were not significant. This is contrary to what was expected as *S. sericeus* in secondary dune strata is characterised by a greater proportion of dead material and is less vigorous and not as succulent as *S. sericeus* on primary dunes (Maze and Whalley 1992). Spinifex node density was also consistently higher on the primary dune than on the secondary dune although a lack of a significant correlation between node density and grazing levels on both primary and secondary dunes suggests that spinifex vegetation density was not influencing wallaby-grazing levels. However, a significant negative correlation of grazing on the primary foredune with dune width suggests lower grazing levels in response to increasingly wider dunes. This may indicate a reluctance of the wallabies to move far from protective cover to graze in exposed dune areas, resulting in a lower utilisation of primary dunes more distant from the woodland edge.

Previous studies have shown that defecation by macropods is associated with feeding activity whilst little defecation occurs in areas used primarily for resting (Hill 1978; Johnson *et al.* 1987). In this study no correlation was evident between faecal pellet counts and spinifex node density for both primary and secondary dunes. Pellet counts were related to spinifex utilisation levels and not to vegetation density, reinforcing the suggestion that wallabies were not selecting the more densely vegetated areas of spinifex in which to feed. For example, a sparsely vegetated area and a densely vegetated area with the same level of utilisation will be likely to have differing levels of pellet counts, suggesting preferential feeding activity in densely vegetated areas.

The terminal end of stolons were highly grazed by wallabies at all sites, even when low grazing was recorded on the primary dunes. The relatively high vigour and succulence of stolons in this region of the dune system could account for these high levels of utilisation (Maze and Whalley 1992). The toe of the primary dune is the site of greatest sand accretion, and therefore an important area in the formation of an incipient foredune (Maze and Whalley 1992). The high utilisation of sand-colonising stolons in this part of the dune system by wallabies may be detrimental and should receive further investigation.

The proportion of open-forest vegetation associated with each site was negatively correlated with grazing levels on spinifex nodes on the primary and secondary dunes. When open-forest communities were not present to any great extent, grazing levels on adjacent dunes were high. This may indicate that the structure and composition of vegetation adjacent to dune systems may be important in determining the amount of utilisation occurring on frontal dunes. In addition, the negative correlation with island width may indicate that the relative area of these vegetation types may also influence utilisation.

Although utilisation of frontal dune vegetation by macropods seems to be significant, a few important questions remain. It is unknown whether *W. bicolor* and *M. agilis* utilise frontal dunes equally or whether the levels of utilisation recorded have the potential to have a significant impact on the *S. sericeus* population, leading to increased erosion. In addition, this study was conducted during late autumn and the relationships established here may vary at other times of the year because of changes in feeding preferences of the wallabies. The secondary dune areas of the frontal dune system are also characterised by the establishment of a number of secondary colonising plant species. The occurrence of some of these other species, such as goats' foot (*Ipomoea pes-caprae*), angular pigs face (*Carpobrotus glaucescens*) and horsetail she-oak (*Casuarina equisetifolia*) seedlings, on secondary dune areas may influence relative dune utilisation. Utilisation of some or all of these species by wallabies may account for some of the variation between spinifex grazing levels and feeding activity of wallabies (pellet counts). It is interesting to note that on many areas of the island browsing on *C. equisetifolia* seedlings by wallabies has resulted in the destruction of a significant proportion of juvenile recruits to the mature stand stabilising the rear of the dune system. A more detailed investigation of the feeding ecology of the two species is required in order to establish the role that frontal dunes play in their ecology.

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Manuscript received 24 May 1993; revised 1 October 1993; accepted 28 October 1993